Vanadium Flow Battery - VFB

Gary Yang

DOE Long Duration Energy Storage Workshop

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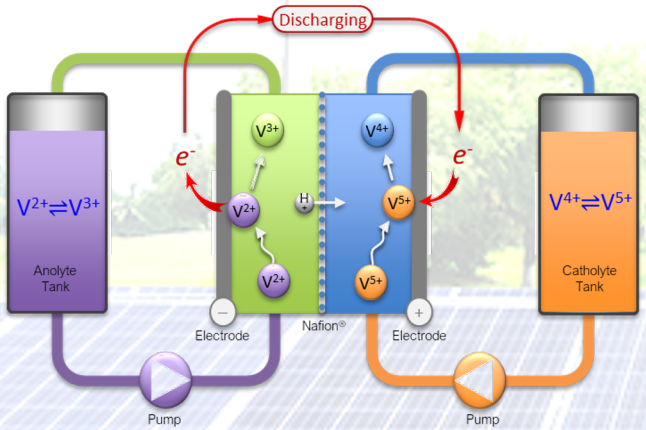
UniEnergy Technologies

An energy storage company that has advanced a new gen VFB to safe, reliable and flexible commercial products, that are:

- Capable of 4-24 hrs durations
- Meeting rapidly increasing demands in renewable integration, C&I, utilities, …



A long journey from molecules to MWs

PNNL DISCOVERY

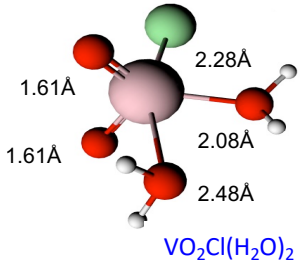
TECH VALIDATION AT SCALES

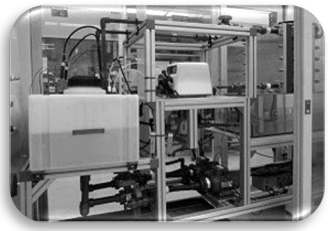
EARLY PRODUCTS

PRODUCT MATURATION

FIELD VALIDATION

MARKET INTRODUCTION





2010

A new gen V chemistry invented at PNNL, demonstrating substantial improvement in VFB

2012

UET founded, with a mission to commercialize the discovery at PNNL

2014

Commissioned 1st container product Uni.System™

2016

Field-deployed 1st MW scale Uni.System™

2018

Rolled out next gen product ReFlex™; built 1st production line at RKP

2020

Field-commissioned ReFlex™; UL/CE certified

Commercial deployment

The decade long journey from molecules to MW is documented in a series of posts in LinkedIn:

https://www.linkedin.com/in/z-gary-yang-96ab864b/detail/recent-activity/posts/

ReFlex™ - Most adaptable VFB battery

- Engineering optimization informed by customer field experience and detailed market analyses

- UL and CE certified!
- New gen V electrolytes
- High power stack
- Air cooling
- Built in auto-balancing
- Compact design
- Highly modularized
- Seamless bypass
- Stack up to MWs
- Shipped ready to run
- 20+ years life

A single ReFlex™ module is rated at 10kW/40kWh and 14kW peak

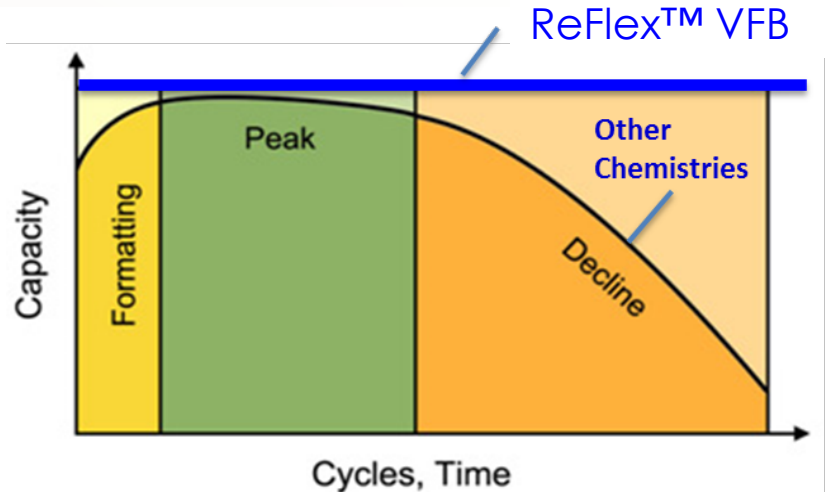
200kW/800kWh AC ***SmartString™*** *Repeating AC product with matching PCS*

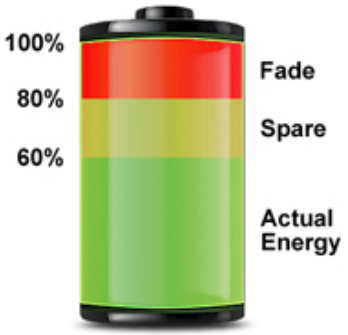
Field-proven reliability, addressing market needs

- Over 100 ReFlex™ modules deployed, accumulating over one million hours with 99% availability

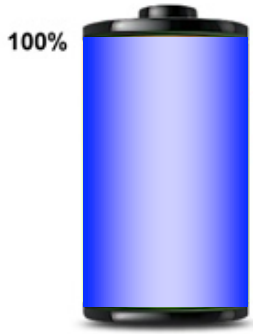
Substantially improved performance

- 2X energy density over conventional VFB, 3~5X footprint reduction
- 25% improvement in V utilization
- Practically unlimited cycles
- No degradation, 100% access to rated energy over a long life
- Unique thermal properties, enabling air cooling even under extreme conditions
- Capable of long durations, only by adding more e'lytes, with <2% self-discharge independent of time.





typical Li-ion useful capacity

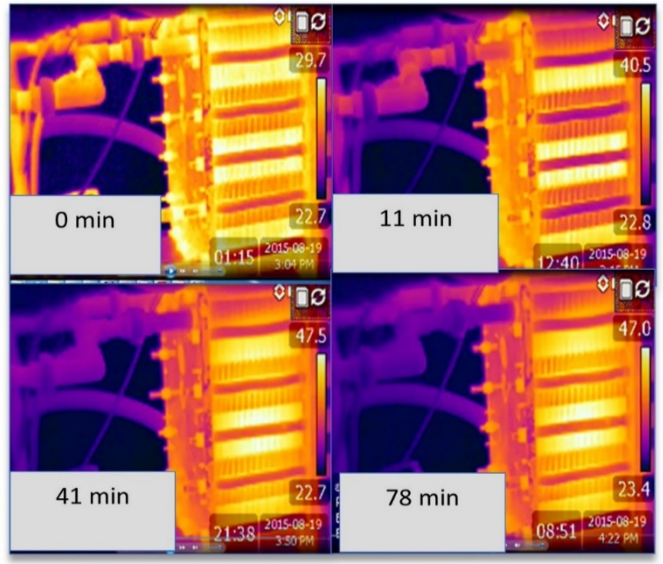


ReFlex™ permanently retains 100% capacity

Inherently safe, sustainable

- Use of aqueous electrolytes
- No thermal runaway
- Even short circuits produce no lasting damage

No VFB fires … EVER!!!



Short-circuiting a fully charged stack with the pumps off only increases temperature 9.1°C. Even this increase is eliminated when the pumps are turned on

Waste to kWhs

Steel slag

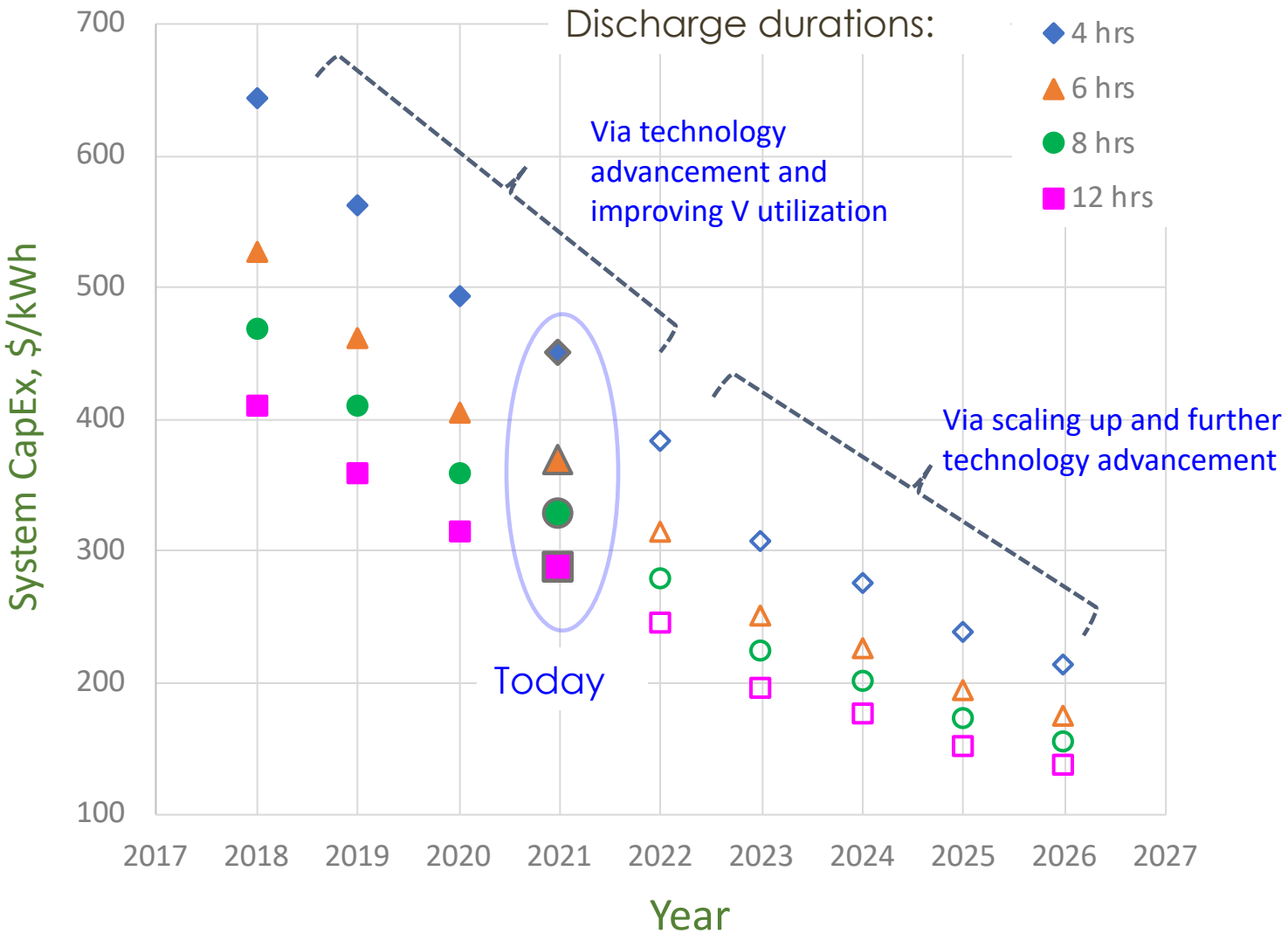
Soot ash

Electrolyte ($V^{3.5+}$)

V chemicals

- E'lytes 100% reusable or recyclable
- E'lytes made from industrial wastes
- V not resource-limited, with 200 ys of identified deposits

Longer duration, more competitive in costs



- Longer duration, more competitive CapEx & LCOE at system level*

  (Unlike Li-ion and other solid-state batteries, only additional e'lytes needed to extend durations.)

- CapEx competitive with ≥ 8hrs durations at system level*
- LOCE already competitive over ≥4 hrs duration
- CapEx & LCOE dropping via scaling up production, building up industry chain, engineering advancement

*DC system including packaging, heat management and other balance of plant

Status and needs of VFB industry

Status & Challenges

- Technology proven: Inherent safe, capable of long durations, unlimited cycles with SOC limits, no degradation, … sustainable
- Struggle in reliability, only few achieved via field-demonstrations and deployments
- Achieved Signiant cost reduction, but much room to drop further, by:
  - Scaling up production
  - Build up industry chain
  - Improve adaptability and application value propositions

Needs

- Government/private partnership in advancing engineering
- Government/private partnership in demonstration and improving value propositions
- "Invent in the US and Make in the US" require private investment and government support in policies to scale up production and build up industry chain in the US.